Predictability of Tropical Intrasesonal variability(ISV) in the ISV Hindcast Experiment

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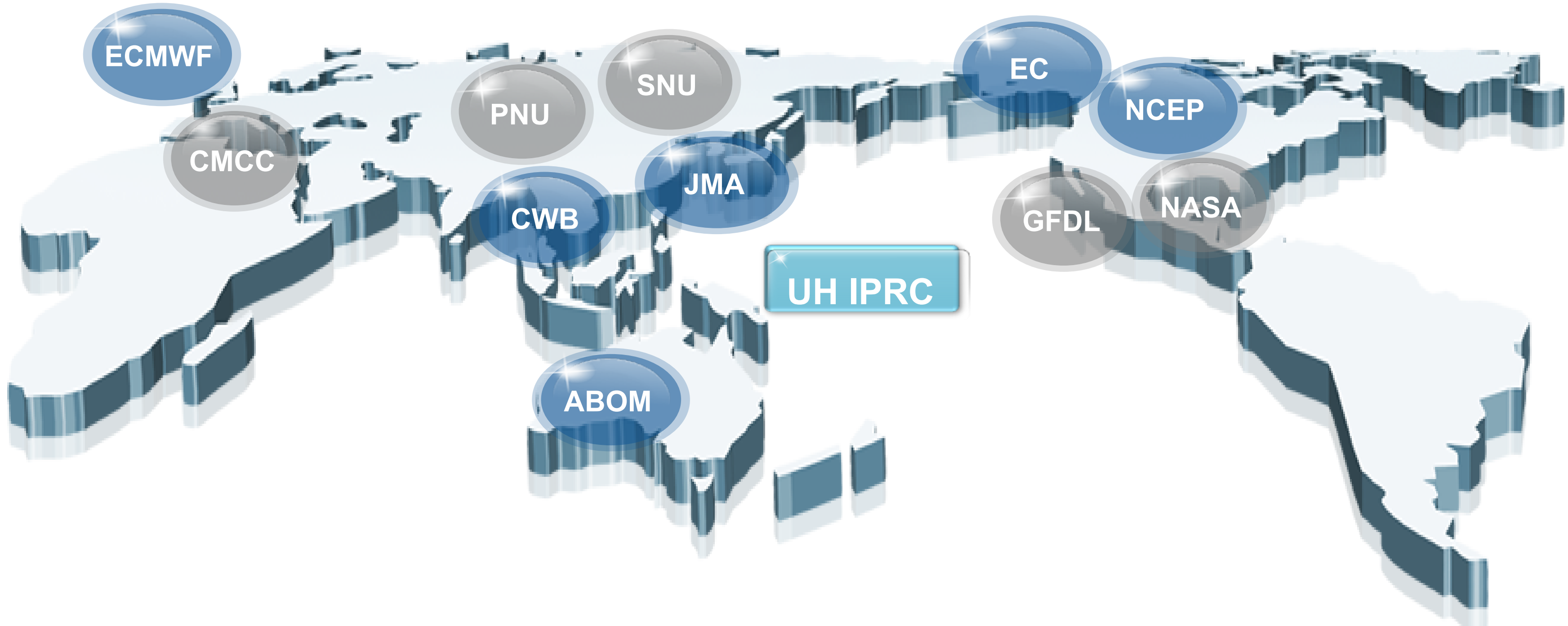
and Participating modeling groups

CLIVAR/ISVHE

Intraseasonal Variability Hindcast Experiment

The **ISVHE** is a coordinated multi-institutional ISV hindcast experiment supported by **APCC, NOAA CTB, CLIVAR/AAMP & MJO WG, and AMY.**



Supporters

Numerical Designs and Objectives

Control Run

Free coupled runs with AOGCMs or **AGCM simulation** with specified boundary forcing for at least 20 years

Daily or 6-hourly output

ISV Hindcast EXP

ISV hindcast initiated **every 10 days** on 1st, 11th, and 21st of each calendar month for at least **45 days** with more than **6 ensemble members from 1989 to 2008**

Daily or 6-hourly output

YOTC EXP

Additional ISO hindcast EXP **from May 2008 to Sep 2009**

6-hourly output

- Better understand the physical basis for ISV prediction develop optimal strategies for multi-model ensemble ISV.
- Identify model deficiencies in predicting ISV and find ways to improve models' convective and other physical parameterization.
- Determine the predictability of MJO in the multi-model frame work.
- Determine the predictability of EPAC ISV in the multi-model frame work.

Description of Models and Experiments

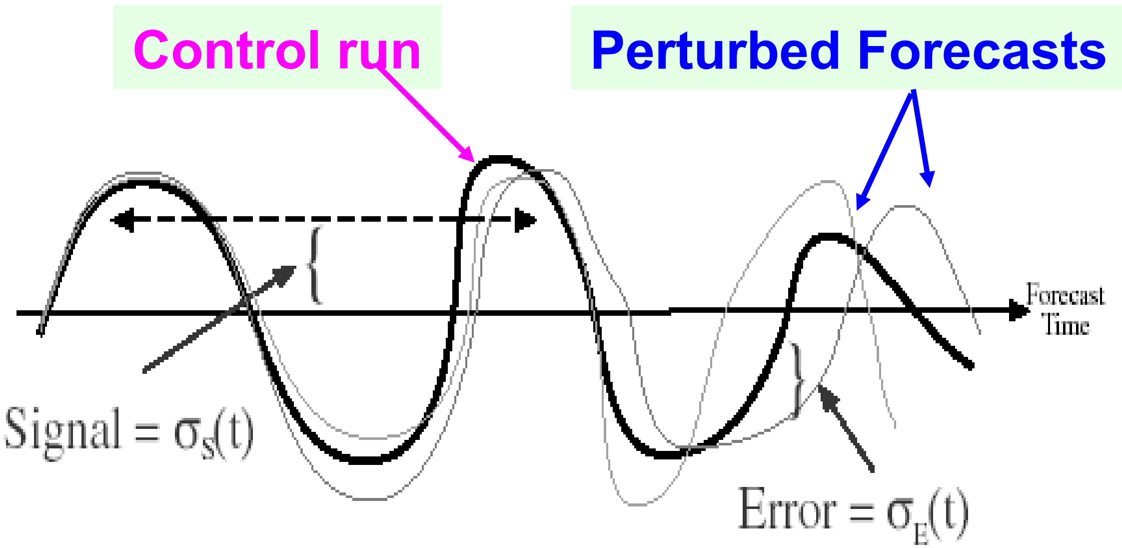
One-Tier System

ISVHE

	Model	ISO Hindcast		
		Period	Ens No	Initial Condition
ABOM1	POAMA 1.5 & 2.4 (ACOM2+BAM3)	1980-2006	10	The first day of every month
ABOM2	POAMA 2.4 (ACOM2+BAM3)	1989-2009	11	The 1st and 11th day of every month
ECMWF	ECMWF (IFS+HOPE)	1989-2008	5	The first day of every month
CMCC	CMCC (ECHAM5+OPA8.2)	1989-2007	5	The 1st 11th and 21st day of every month
JMA	JMA CGCM	1989-2008	5	Every 15th day
NCEP/CPC	CFS v1 (GFS+MOM3)	1981-2008	5	The 2nd 12th and 22nd day of every month
NCEP/CPC	CFS v2	1999-2010	5	The 1st 11th and 21st day of every month
SNU	SNU CM (SNUAGCM+MOM3)	1990-2008	4	The 1st 11th and 21st day of every month

Signal to Noise ratio estimate ISV predictability

Waliser et al. (2003)

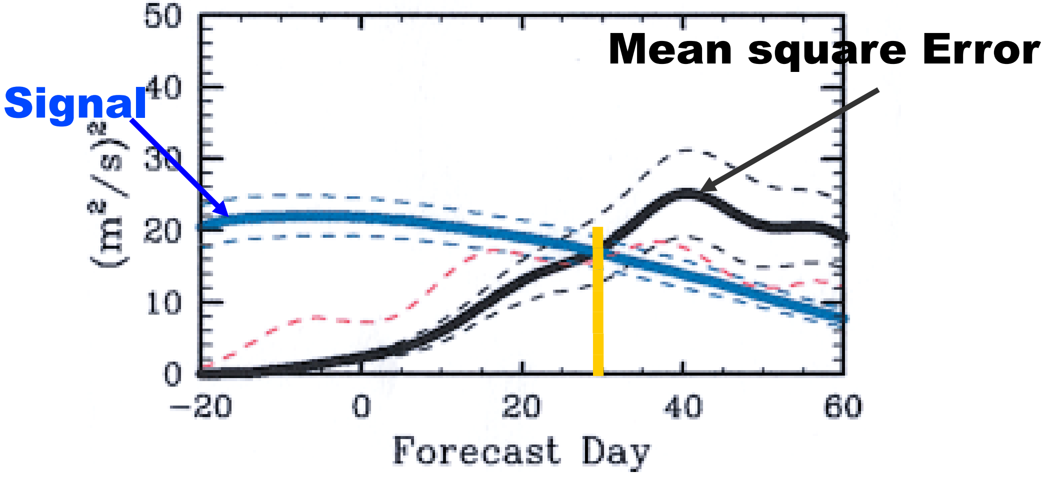


Signal (L=25 days)

$$\sigma^2_{S_{ij}} = \frac{1}{2L+1}\sum_{\tau=-L}^{L}(X^0_{i,j+\tau})^2$$

Noise: Predictability Error

$$\sigma^2_{E_{ijk}} = (X^k_{ij} - X^0_{ij})^2$$



Predictability of winter MJO in the ISVHE multi-model framework

MJO Predictability estimates based on the RMM indices

Bivariate estimates of Signal and noise

Single member Predictability estimate

Error -- Difference between hindcast RMM1 and RMM2 values for two ensemble members.

Ensemble mean Predictability estimate

Error -- Difference between hindcast RMM1 and RMM2 values for an individual ensemble member and the ensemble mean of all other members.

i- initial condition
j- hindcast lead

$$E_{ij}^2 = \left(RMM1_{ij}^{k1} - RMM1_{ij}^{k2}\right)^2 + \left(RMM2_{ij}^{k1} - RMM2_{ij}^{k2}\right)^2$$

Signal- Combined RMM1, RMM2 variance in a 51 sliding day window in individual ensemble member hindcasts.

L=25

$$S_{ijk}^2 = 1/51 \times \sum_{t=-L}^{L} \left(RMM1_{i\,k\,j+t}\right)^2 + \left(RMM2_{i\,k\,j+t}\right)^2$$

MJO Predictability in the ISVHE models

Single member predictability estimates

Min ---18 days (ABOM2)
Max--- 27-28 days (ABOM1, ECMWF, CFS2)

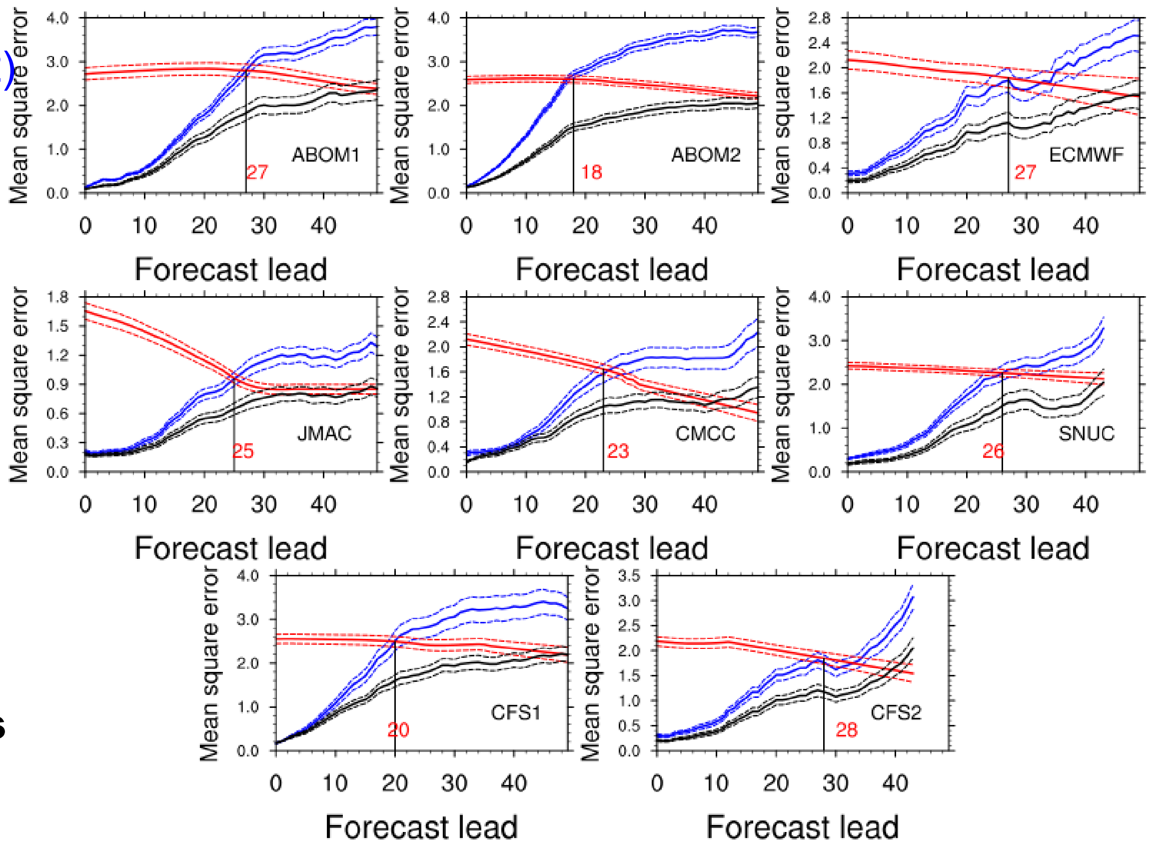
Average estimate from eight models ---- 24 days (s.d. of 3.6 days)

Ensemble mean predictability estimates

Min ---35 days (JMAC)
Max--- 50 days (ABOM2)

Average estimate from eight models ---- 43 days (s.d. of 4.7 days)

Signal- Red curve
Single member error- Blue curve
Ensemble mean error-Black curve



Neena et al, (submitted)

In most models the MJO is predictable for 20-30 days by individual ensemble member hindcasts and by using ensemble means the predictability of MJO can be extended up to 40-50 days.

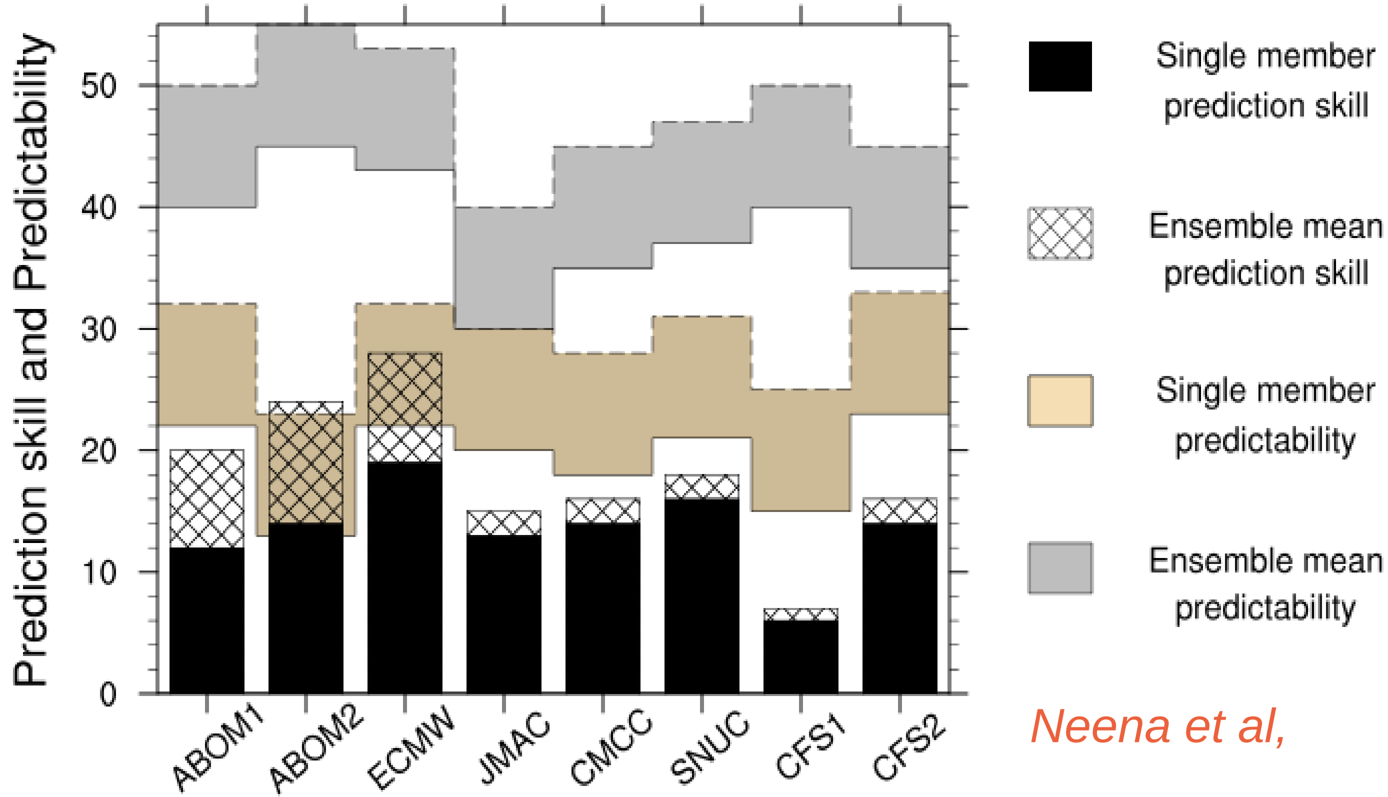
MJO prediction----Where do we stand?

Average single member prediction skill for MJO ----2 weeks!

Remarkable improvement for ensemble mean prediction skill ABOM1, ABOM2 and ECMWF.

ECMWF model shows maximum skill for both single member (19 days) and ensemble mean (27 days) predictions.

* Predictability estimates are shown as +/- 5 day range



Neena et al,

Present day prediction capabilities for the MJO can be extended by at least one more week in all the eight dynamic models.

Ensemble mean prediction skill holds more promise --- there is scope for improving further by at least 3 more weeks.

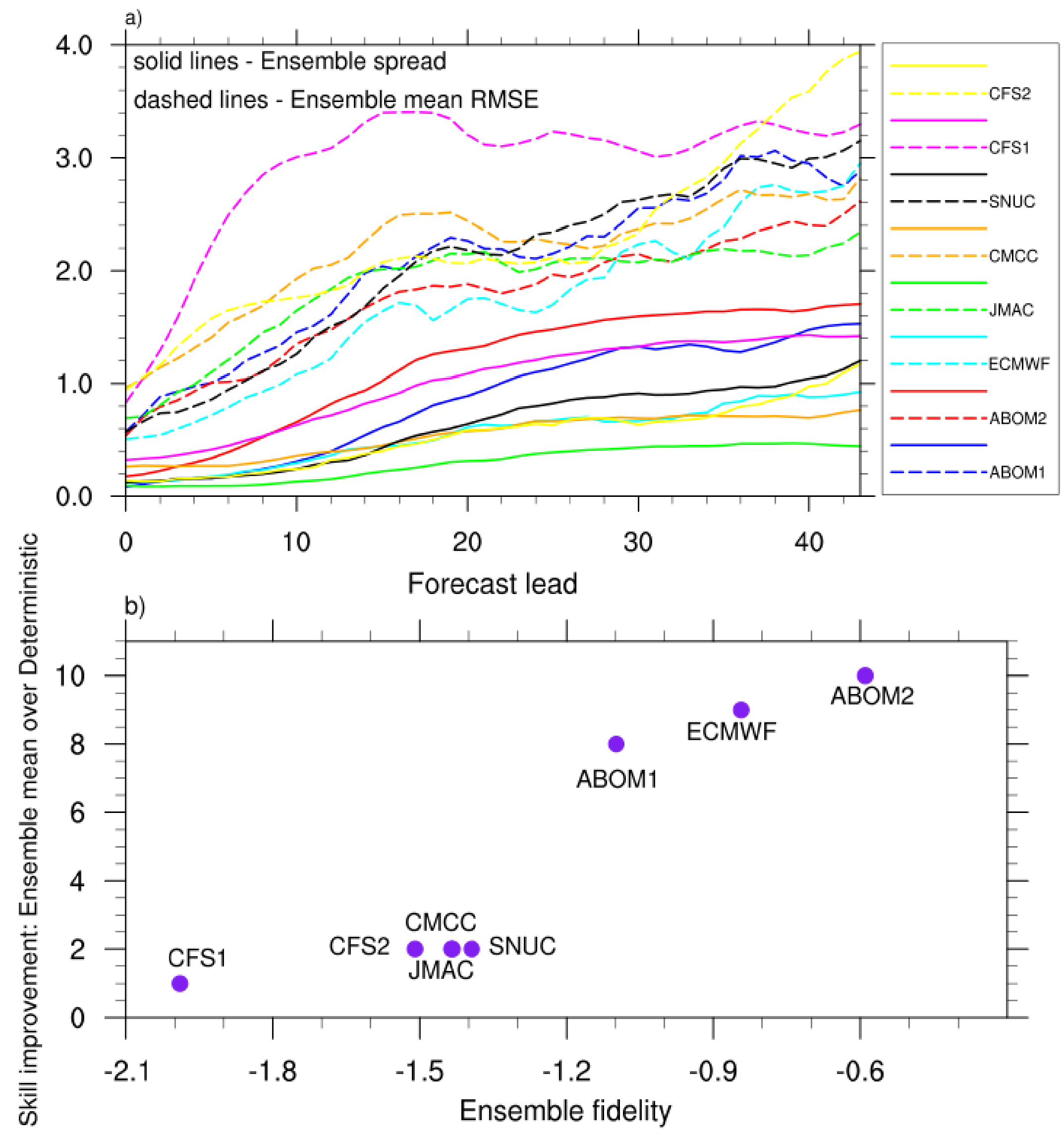
Suitable ensemble prediction systems are crucial for MJO forecasting.

Ensemble fidelity and improvement in prediction skill for MJO

In a statistically consistent ensemble, the RMS forecast error of the ensemble mean(dashed) should match the standard deviation of the ensemble members (ensemble spread) (solid).

Ensemble fidelity is defined as the average difference between the solid and dashed curves over the first 25 days hindcast

Models with more statistically consistent ensembles for the MJO show better improvement in the ensemble mean prediction skill over the inidividual ensemble member hindcast skill!



Predictability of summer Eastern Pacific (EPAC)ISV In theISVHE multimodel framework

Eastern Pacific ISV

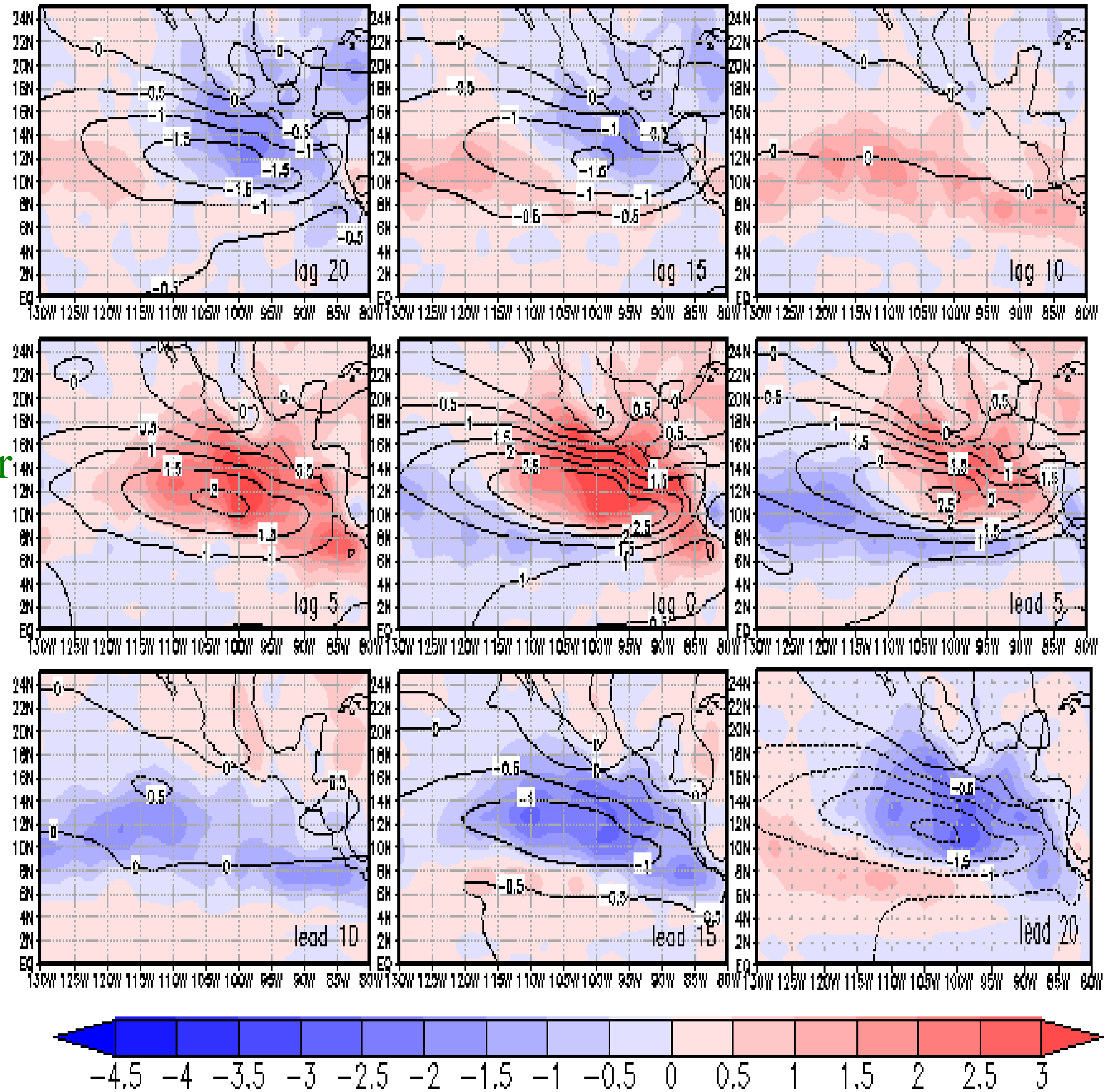
The eastern Pacific warm pool represents a region of strong ISV during boreal summer.

The 30–50 days EPAC ISV mode is characterized by both eastward as well as northward propagation (e.g., Jiang and Waliser, 2008, Maloney et al, 2008).

A quasi biweekly mode was also identified over the EPAC. Jiang and Waliser (2009).

Here, the EPAC ISV mode is isolated using combined EOF analysis of 20-100 day filtered TRMM precipitation and U850 over 230-280E, 0- 20N.

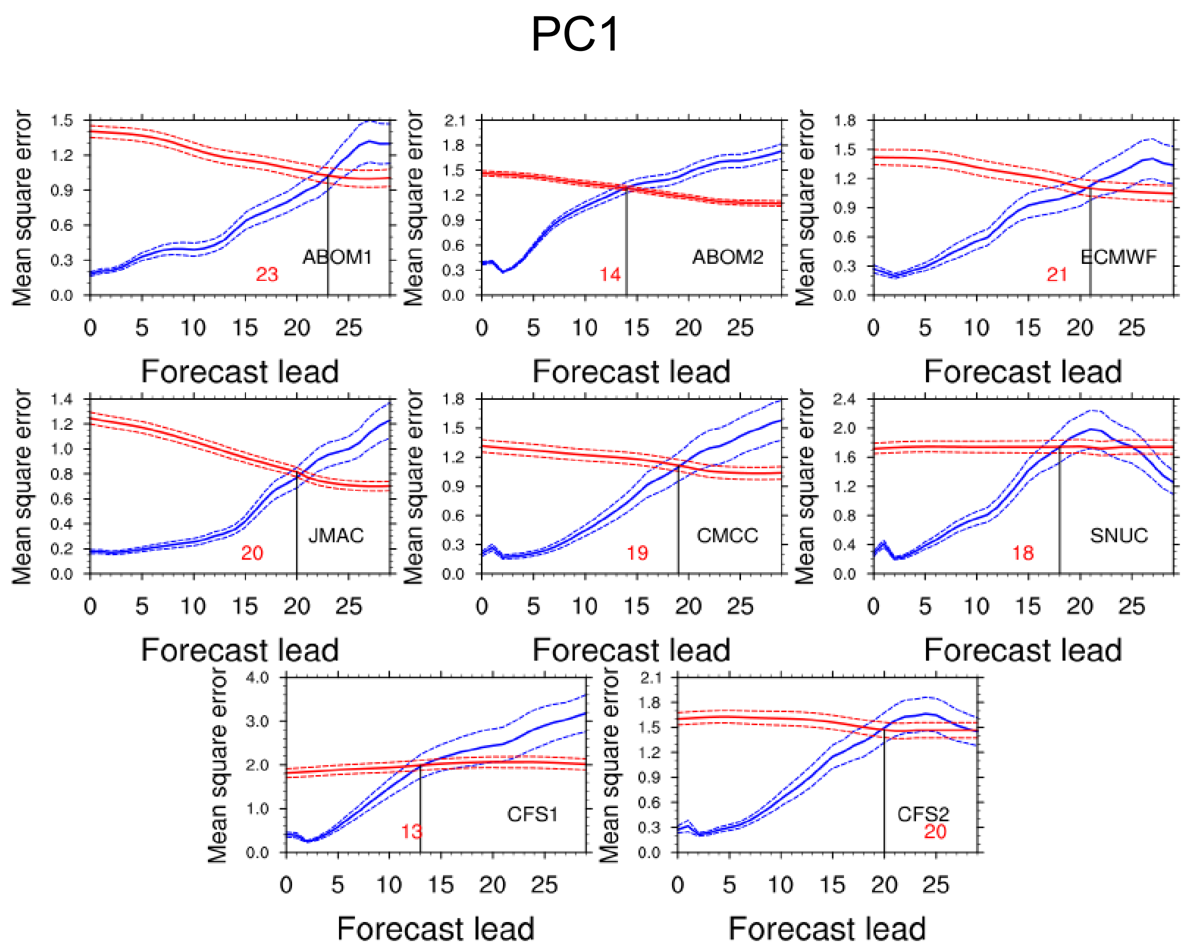
CEOF1---32% variance
CEOF2---9% variance



Regressed 20-100 day filtered precip(shaded) and u850(contour) anomalies wrt PC1

EPAC ISV Predictability in the ISVHE models

The approach is similar to the MJO predictability study, except here the estimates are based on the PC obtained by projecting 5 day smoothed anomalies onto CEOF1.



Single member predictability estimates

Min ---13-14 days (ABOM2, CFS1)
Max--- 23 days (ABOM1)

Average estimate from eight models
---- 19 days (s.d. of 3.4 days)

Work in progress...

A 2-3 week predictability is observed for the EPAC ISV mode, the predictability may be higher for the ensemble means. PC2 exhibits a predictability around two weeks.

EPAC ISV prediction skill

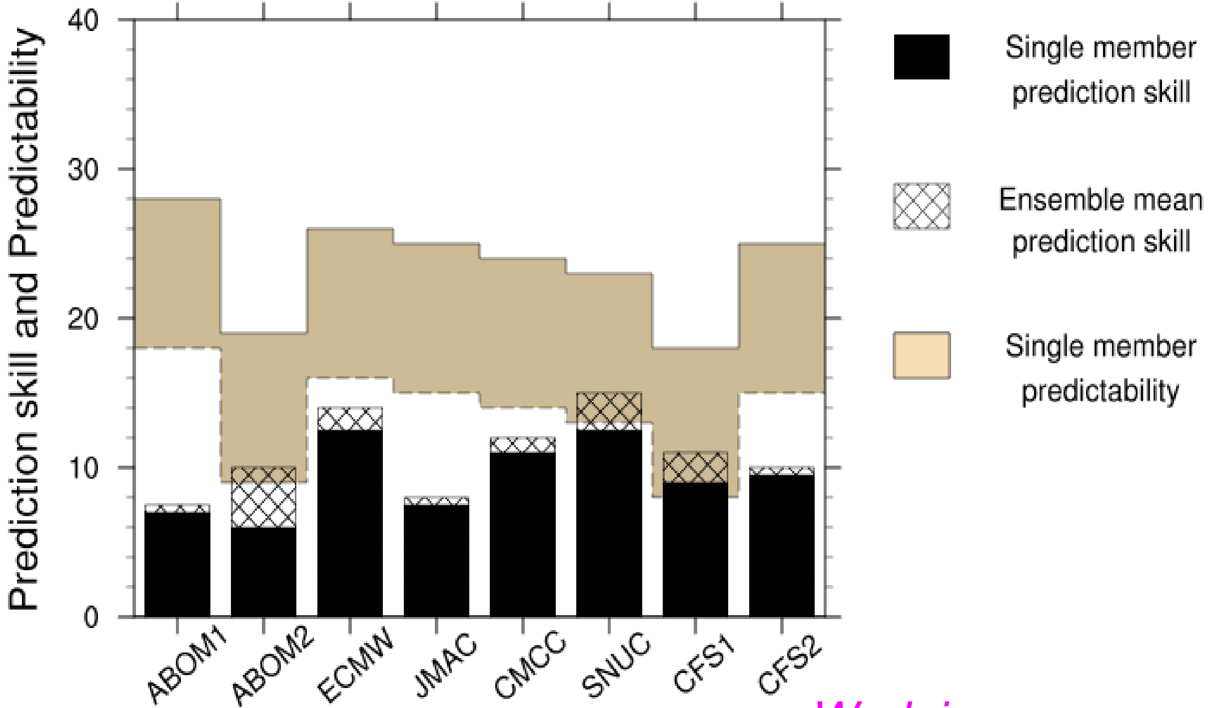
Average single member prediction skill for EPAC ISV ----9-10 days!

Ensemble averaging does not improve the EPAC ISV prediction skill by a large amount.

The ABOM1 and ABOM2 models which shows higher prediction skill for MJO performs poorly for EPAC ISV.

ECMWF and SNUC are the better performers over EPAC.

* Predictability estimates are shown as +/- 5 day range



Work in progress...

There is a large possibility for improving the EPAC ISV predictions in most models.

The notable feature is the lack of improvement in ensemble average forecasts.

An average 15-25 day predictability exists for the EPAC ISV mode across the eight models.

Summary

The predictability of winter MJO and summer EPAC ISV is investigated in the ISVHE hindcasts of eight coupled models.

- A 20-30 day predictability for indiviual ensemble member MJO hindcasts and a 40-50 day predictability for ensemble mean MJO hindcasts is observed.
- Present day MJO prediction capabilities can be extended further by at least one week for individual ensemble forecasts in most models. Ensemble mean prediction skill improvement holds more promise.
- In addition to improving the dynamic models, devising ensemble generation approaches tailored for the MJO would have a great impact on MJO prediction.
- For the EPAC ISV, a 15-25 day predictability is observed in individual ensemble member hindcasts.
- Ensemble average forecasts does not show much skill improvement over the EPAC.

J.M. Neena, J-Yi Lee, D. Waliser, B. Wang and X. Jiang : Predictability of the Madden Julian Oscillation in the Intraseasonal Variability Hindcast Experiment (ISVHE), J Climate (submitted).

THANK YOU !!!

Special case – Predictability dependence on MJO amplitude

Signal- Red curve
Single member error- Blue curve
Ensemble mean error-Black curve

Weak MJO Vs [Strong MJO]

Single member predictability estimates

Min --- 13 days [18 days]
Max--- 27 days [27 days]

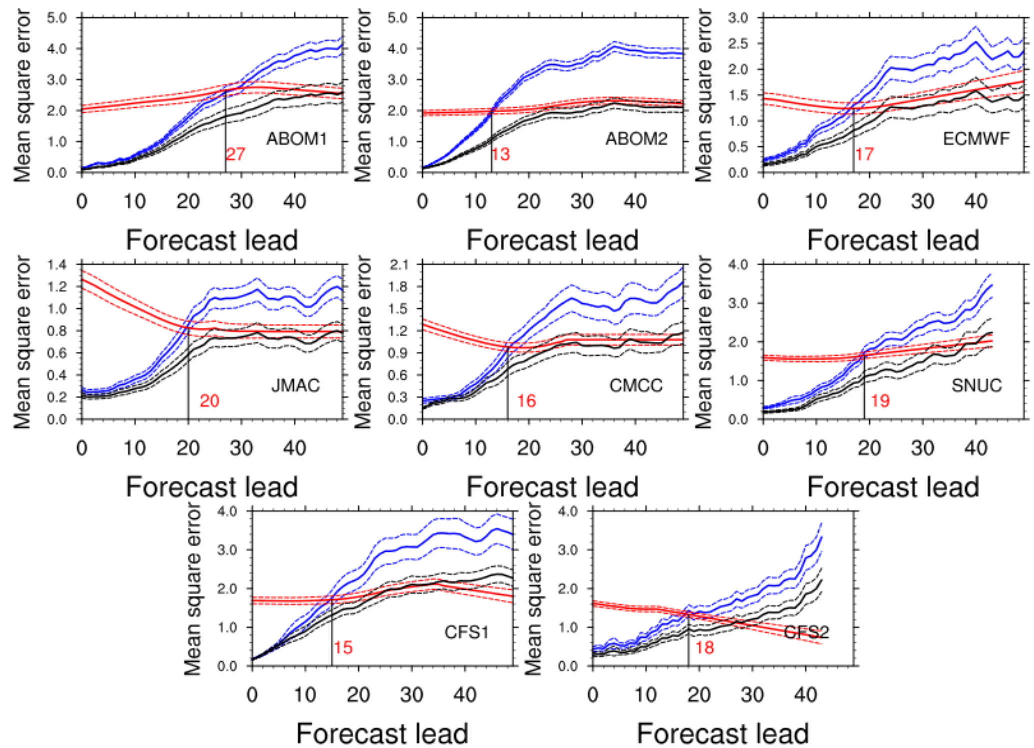
Average estimate from eight models ---- 18 days [24 days]

Ensemble mean predictability estimates

Min --- 22 days [35 days]
Max--- 46 days [50 days]

Average estimate from eight models ---- 29 days [43 days]

Choosing only those hindcasts for which RMM amplitude is <1.0 S. D. during hindcast initiation



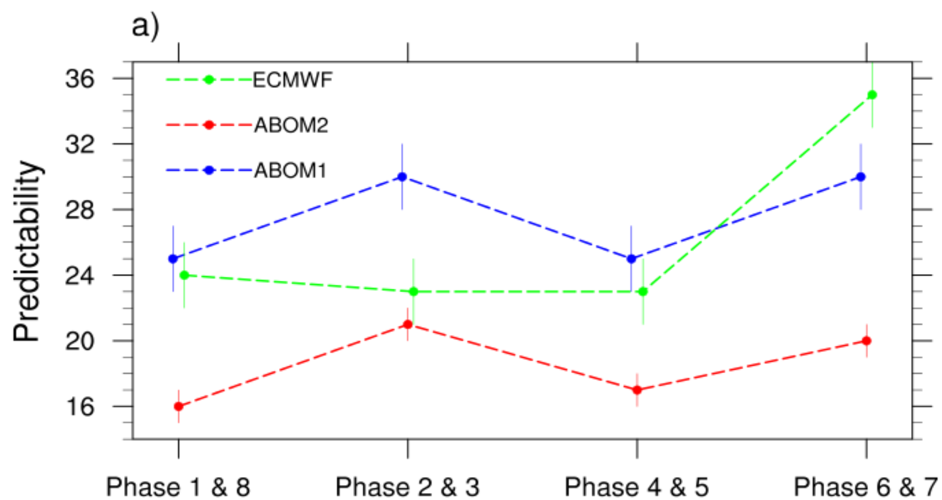
The single member (ensemble mean) estimate of MJO predictability is lower by one week (two weeks) for weak MJO, in all models except ABOM1

Special case – Predictability dependence on MJO phase

a) Hindcasts are grouped according to the RMM phase during hindcast initiation
b) Hindcasts are grouped into those associated with primary/secondary MJO events using the RMM index based classification of Straub (2012)

Only 3 models exhibit such phase dependence of predictability.

For these models, MJO predictability is higher for hindcasts initiated from MJO phases over Indian Ocean and Western Pacific



Hindcasts initiated from secondary MJO events have longer predictability than those from primary events